Review Article

A Review on Crop Regulation Techniques in Guava (*Psidium guajava* L.) through Hi-Tech Practices

ABSTRACT

Guava (*Psidum guajava* L.) is one of the most favorable fruit crops in India and is considered to be a well-executed, nutritionally valuable and profitable crop. Recently, guava has secured higher demand within the global trade because of its nutritional value and processed products. It is a hardy, prolific bearer and produces a fairly remunerative fruit crop. It is mainly cultivated on a large commercial scale. Guava fruit bears three bahar seasons, *viz.*, Ambe bahar, Mrig bahar, and Hasth bahar. The continual bearing habit ends up in the reduction of yield with the inferiority of small-sized fruits. So as to overcome this problem, bahar treatment is practiced. Among the three bahar seasons, the heaviest flowering is observed in the Ambe Bahar season, but the fruit quality of this season is rough, watery, insipid in taste, poor in quality, less nutritive and is heavily attacked by many insects, pests and diseases. The fruit quality of winter season crops is excellent, nutritive, and escaped from the attack of fruit flies. Therefore, the crop regulation practice is to force the tree for rest and produce profuse blossoms and fruits throughout any one of the two or three flushes. It is necessary to reduce the fruit set during the rainy season and subsequently increase the fruit set during the winter season through the use of various chemicals like NAA, ethereal and urea etc to regulate the guava crop. This method aims at regulating uniform and good quality fruit and also maximizing produce as well as profit. This regulation method depends on climatic factors, cropping pattern, extend of the damage by the disease and pests, market and industry demand, cultivar, etc. Crop regulation is accomplished by the various strategies like water management to induce stress, training and pruning of shoots and roots at different levels as well as at different times and manual or chemical thinning of flowers.

Keywords: *Crop regulation; guava; productivity; quality*

1. INTRODUCTION

Guava (*Psidium guajava* L.) is the fifth most promising commercial fruit crop in India. It belongs to the family myrtaceae, is native to tropical America, and is one of the most important tropical and subtropical fruits. It is easily available in the market and offers a reasonable price. It is thus named as Apple of Tropics and Super Fruit for its rich nutritional values [1,2]. It is also called the "Poor Man's Apple". It is a decent source of Vitamin C (150-200 mg/100 g of pulp). It has gained considerable prominence and consumer access on account of its high nutritive value. Guava fruit contains antioxidant properties that control the systolic pressure level. Guava fruits have three distinct flowering seasons viz spring (Ambe Bahar), rainy (Mrig Bahar) and autumn (Hasta Bahar), with the corresponding harvesting periods during the rainy, winter and spring seasons [3]. There are Ambe bahar- february to march flowering and their fruit ripens in july – august, Mrig bahar – june to july flowering and their fruit ripens in october to december as well as Hasth bahar – october to november flowering and fruit ripens in february to april [4]. The heaviest flowering is observed in rainy season cropping because of profuse humidity and emergence of current shoots which bears fruit bud in leaf axils and fruit. But, the bearing fruits of rainy season crop are rough, insipid, poor in quality, less nutritive and are attacked by several insect pests and diseases [5]. On the other hand, fruits in the winter season are superior in size, quality, taste, aroma and also crop; they

are free from diseases and pests so; they get a higher price than in the rainy season with better demand in the market [6]. Because winter crops have a longer storage life, they can be transported at competitive prices [7]. However, it is desirable to take only one crop every year. This requires various managements of flowering to obtain the most desirable crop, by different methods like withholding irrigation, pruning and flower thinning by chemically or manually. Therefore, various scientists and their coworkers reviewed crop manipulation under different subheads.

2. CROP REGULATION AND ITS IMPORTANCE

The purpose of crop regulation is to force the tree to rest and produce profuse blossoms and fruits. It can be achieved through with holing irrigation water, root exposure, root and shoot pruning, deblossming, spray of chemical and other plant growth regulators. Several crops that bloom more than once a year do not produce a good yield and quality of fruit throughout the year. In guava, the summer season (Ambe bahar) bears more flowers due to the break of winter stress. So, it produces more fruit during the rainy season. However, in this season due to high temperature and rainfall during fruit maturation, the duration of fruit maturation is reduced to 30 days that causes excess in the market while winter season crop (Mrig bahar) is superior in quality which obtains remarkably higher price. However, the rainy season guava bears excess fruit production [3, 8], but it offers poor quality due to insipid taste and pest infestation compared to the winter season [9]. On the contrary, the fruit quality of the winter season is good, and free from diseases, pests and fetches high monetary returns [10]. Guava fruit harvest peaks can vary with prevailing weather conditions and cultural practices because flowers are induced on new growth. Therefore, far getting the quality fruits in guava only winter season crop should be taken comparatively to rainy season crop. This requires the regulation of flowering to obtain the most desirable crop by withholding irrigation, thinning of flowers through chemically or manually, pruning, bending, root exposure, etc. In different regions various methods of crop regulations are followed which depend upon the climatic factors, cropping pattern, cultivar etc. Crop regulation is practiced in guava to encourage particular season crop so as to induce quality fruit with high commercial value. The fundamental principle of crop regulation is to manipulates the natural flowering and fruiting of guava plant in desired season of the year that contribute to accumulated fruit yield, quality, profitability and property of the surroundings by reducing the utilization of the frequency of the pesticides [11]. This idea relies on the actual fact that guava flowers are borne solely on new, succulent, smartly rising vegetative growth. These new growth flushes are either new emergences of lateral buds on older stems or extensions of already established terminals of varied size and vigor.

3. METHODS OF CROP REGULATION IN GUAVA

“Several methods have been used to induce new vegetative growth during the rainy season so that more crops are obtained in the subsequent winter season” [10]. The following practices carried out by various scientists on crop manipulation are reviewed under different subheads in order to get the fruit crop in the winter season.

a) Withholding irrigation method

In guava, the induction of water stress by withholding irrigation after harvesting of the winter crop results in the shedding of flowers and the trees go to rest. The operations of withholding water exhibit feeding roots and also prune the fibrous roots to force blossom in the desired season. June flowering is inspired to get a winter crop; for that, the basin of the tree is dug up, manured, and irrigated in June. After 20-25 days of fertigation, the tree offers profuse flowering in July and fruiting in the winter season. Water stress may be induced by practices like root exposure and root pruning. It has been suggested that withholding of water and removing the earth from around the upper roots by 10th June and again covering it with soil and manure mixture [12]. Two irrigations were also suggested before a normally heavy one when the rains did not start. Likewise, it has also been suggested that the root pruning practice is done along with withholding irrigation in heavier soils during December or January [13].

b) Bending method of guava shoots

The bending method is very much dependent on the training of guava branches. On the basis of the calculation of expected flowering, the branches of guava plants are bent down about 45-60 days before the expected date of flowering to produce fruits in the off season. Initially, bending of branches of guava plants ought to be done at the age of 02 (two) years of the plant. Before bending the leaves, small shoots, flowers, and fruits from the branch are removed or cut off, keeping 10- 12 inches of terminal twigs intact. During autumn (September-November), the new shootlets take 20-25 days to emerge. Bent branches ought to be untied once the new shootlets are about 1 cm in length. Flowering occurs in the new shootlets at 4-5 pairs of leaf stage after 45-50 days of summer and 60-65 days of autumn bending. Manures and fertilizers should be applied 15 days before the bending of branches and again at the peak stage of fruit growth followed by irrigation [14].

c) Hand thinning method

"It is possible to regulate the cropping pattern in guava by hand thinning of flower buds and thinning of flowers during the months of March and April in Red Flushed, Allahabad Safeda, and Sardar varieties which has proved to be the most effective in reducing the size of the rainy season crop by withholding water" [15].

d) Pruning and exposure techniques

"Annual pruning is used as a cheap and effective culture technique for regulating the cropping pattern and increasing fruit yield and quality in guava" [16]. "It has been reported that the maximum number of fruits in a winter crop is found from guava trees when three-fourths of the shoot length is pruned during May [14]. The practice is popularly known as elicit treatment and is achieved by root exposure and root pruning or exposure to hot sun before the onset of monsoon. Root pruning, however has a harmful effect on the longevity of trees" [17]. "It has been studied that the effect of pruning on vegetative growth, flowering, and fruiting in Sardar guava favored the production of more flowers in the July-August flush thereby more fruits in the winter season". [17,18]. In addition, 50% shoot pruning of guava cv. L-45 (Sardar) in May produced the highest fruit yield of any winter crop [17].

e) Deblossoming techniques

Some of the plant growth regulators (NAA, NAD, 2, 4-D, carbaryl and ethrel) or certain chemical compounds have been found very effective in thinning of flowers, increasing the winter crop as well as manipulating the cropping season under different agro-climatic conditions. Post-bloom application of NAA @ 80- 100 ppm has been useful in reducing fruit set. This treatment can reduce more than 80 % of the rainy season crop and also increase flowering of the winter crop. The spray of 2, 4-D @ 30ppm was also found to be effective for de-blossoming in summer flowers. "Manual deblossoming of rainy season flowers at small scale, kitchen garden and early age of the plant is very effective as compared to large commercial plantation. Flower thinning by using naphthalene acetic acid (NAA), naphthalene acetamide (NAD), 2,4-dichlorophenoxy acetic acid (2,4-D), potassium iodide (KI), ethephon, 4,6-dinitro-ocresol (DNOC) and urea has been tried with varying degrees of success. This variation may be due to cultivars, tree condition, soil type, and environment. Most of the workers are of the opinion that chemical thinning is economical, as it increases the winter yield and also helps in improvement of fruit quality. In guava, deblossoming with NAA @ 600ppm prevents flowering and cropping during the rainy season in order to augment cropping in the winter season. It has been found that 15 per cent urea at 50 per cent bloom stage showed the most effective in deblossoming during the rainy season guava crop" [19]. "Similar results have been reported by Tiwari and Lal (2007)" [20].

4. Effect of crop regulation on floral and yield parameters

"In general, guava trees bear flowers twice a year, i.e. in April-May and August-September, so that fruits ripen in the rainy and winter seasons severally" [21]. "Sometimes, a third flowering happens in October-November, particularly in Maharashtra and Tamil Nadu" [22]. Floral buds seem to open presently once the break of winter stress and new growth starts in the axil of the leaves of guava crop. Flower bud seems produce after the maturation of first pair of leaves, but there is no direct association between leaf appearance and flower production [23]. Flowers occur either on an individual basis or in determinate of 2-

3 at leaf axils of current [24]. The bearing twigs usually grow a few centimeters, putting forth 4-5 pairs of leaves and thereafter, either flower buds start developing or twigs cease to grow till the next season. These are the following floral and yield parameters affected by crop regulations.

a) **Number of flowers: "**The flower number in guava depends upon the season, varietal selection, and varied cultural operations, including PGR, etc. In pruned trees of guava, 70 to 83 per cent of laterals flowered, whereas in unpruned trees, 40 to 60 per cent of laterals floral and the flower initiation and flower production were also hastened" [25]. "Similarly, there was also observed that tipping terminal portion of tender shoot hastened the production of flowers per shoot compared to untipped shoots in guava" [26]. "There was also observed that the annual pruning of guava stimulated the flowers" [27, 28].

b) **Fruit set: "**To influence the guava crop within the desired season, it is essentially to reduce the fruit set during the rainy season and thereafter increase the fruit set during winter season by the use of different chemicals" [29], [30]. It has been recorded that the reduced fruit set during the rainy season with a spray of NAA@1000 and 2000 ppm [31]. Similar results were also obtained when spraying of NAA @ 600 ppm [32]. When application of high concentration of urea affects fruit set during the rainy season [33]. Similar results were obtained when a 10% urea solution was used to reduce fruit set [34]. It was also reported that the withholding irrigation method also reduces the fruit set in guava during rainy season crop [35]. Similar findings were found in root exposure and root pruning methods [36]. "There was obtained maximum fruit set during monsoon by 30 cm shoot pruning" [37].

c) **Fruit size: "**It depends upon the number of fruit seasons and the genetic makeup of the variety. It was reported that pruned trees of guava produced larger fruits than unpruned trees" [38]. Similar results were also observed that pruning of guava trees increased fruit size [37]. When thinning of flowers and young fruits is done, the size of the fruit will increase [29]. "The fruit length and fruit diameter were also increased by the use of growth substances" [29,38]. "The fruit size improved in both rainy and winter season crops by the utilization of various thinning chemicals" [29,39]." However, it was reported that all NAA, urea, ethephon, and potassium iodide treatments improved guava fruit size during the rainy and winter seasons, but fruit length was found to be greatest in 10% urea" [40]. Similarly, it has also been seen that the maximum fruit size increases with the with application of 10 per cent urea during rainy season [41].

d) **Fruit weight:** Generally, it depends upon the number of the fruits in season and the genetic makeup of the variety, in addition to other cultural practice. It has obtained increased fruit weight found in Allahabad Safeda through crop regulation practices [24]. Similar results were obtained by manual removal of flowers to increase fruit size in the Sardar variety of guava [29]. When the application of growth substances like NAD (30 and 50 ppm) to increase fruit weight [29]. Likewise, it has also been reported that the application of various chemicals increases the fruit weight of guava plants during both rainy and winter season crops [42]. The use of NAA at 600 ppm during the full bloom stage to increase fruit weight [43]. The application of NAA @ 100 ppm at full bloom stage same type of results were produced [34]. However, "it had reported that all treatments like NAA, ethephon, urea and potassium iodide improved the mean fruit weight of Sardar guava and the maximum fruit weight with the application of 10 percent urea spray during both rainy and winter season crops" [40].

e) **Fruit yield: "**The fruit yield is an ultimate factor that decides the success and failure of any technology in the favors of the fruit growers. The rainy season crop found minimum effectively by the use of various chemicals and also obtained a subsequent good winter season crop" [30]. Similarly, "it was reported that a good winter crop obtained when rainy season crop reduced effectively with the spray of NAA @600 ppm" [21]. "There was also reported that one leaf pair pruning decreased the fruit yield per tree during rainy season and subsequently increased the fruit yield during the winter season" [44]. Similarly, "it obtained the highest yield in lightly pruned

(30cm) guava trees and the lowest in severely pruned guava trees during the rainy season" [37]. However, pruning done in the current season's growth of spring flush is advocated to avoid the rainy season crop and to get a subsequent good winter crop [42]. Likewise, it was reported that pruning of half the current season's crop and a subsequent good crop in winter season [45]. Similar observations were also made by Singh and Kumar,1993 [46]. Hand thinning of flowers reduced the rainy season yield and increased winter crop but total annual yield was lower [29]. Hand thinning of flowers too expensive and cumbersome, so these practices commonly not used [27,42].

5. EFFECT OF CROP REGULATION ON QUALITY CHARACTERS

The purpose of the crop regulation is to manipulate the natural flowering of the guava plant in a preferred season that contributes to improved fruit yield, quality, and profitability. Therefore, some important quality parameters are affected by the crop regulation practices, which are as follows:

a) **Sugars: "**The sugar content of fruit from pruned and chemically treated guava trees is influenced in both seasons of cropping. There was reported that pruning method helped in increasing the total sugar content of guava fruit" [37]. Similar results were also observed that increased total sugar contents due to pruning in both the seasons [47]. Whereas the addition of NAD@30 ppm raises the total sugar content of guava fruits [29]. "Different chemical treatments such as NAA, ethephon, and urea had a significant effect on the percentage of total sugar content during rainy and winter season guava fruits" [48].

b) **Total soluble solids (TSS): "**Total soluble solids is the index of fruit sweetness. Various thinning treatments were found to be superior in improving the TSS content of guava fruits throughout the rainy and winter seasons" [49]. "It was found to have a significant improvement in the TSS content with potassium sulphate @1% once sprayed 07 days after fruit set in guava and six more times at weekly intervals" [50]. Similarly, "they obtained the improved TSS content with the spray of potassium iodide at flowering time in guava during both rainy and winter season crops" [39]. Whereas, "it was also observed an appreciable improvement in TSS content with totally different chemical treatments (NAA, 2, 4-D, DNOC and urea) as compared to control during both rainy and winter season crops of Sardar guava" [34]. Likewise, "it was recorded the higher TSS content with spray of urea@10% at full bloom stage of guava during both rainy and winter season crops" [43]. "Similar results were also obtained by Bariana, 1988 [41]. Pruning resulted in better quality fruits during the rainy season" [51] . "Five Navalur guava cultivars yielded similar results" [52].

c) **Vitamin C:** The antioxidant content of guava fruit is influenced by the varied crop manipulation treatments. The work carried out by the various workers is summarized as under more vitamin C content was recorded in a variety of Allahabad Safeda during the winter season (241.66 mg/100 g) by pruning treatment compared to the rainy season (90.66 mg/ 100 g) [47]. Application of 12 ppm 2, 4-D increased vitamin C content (202.18 mg/100g) [53]. Similarly, it was also found that maximum vitamin C content with the spray of NAA@125 ppm in both the rainy (174.6 mg/kg) and winter (253.7 mg/100g) seasons [29].

d) **Acidity:** In general, the acidity of the fruit varies with the seasons, i.e. in summer, acidity is usually lower as compared to the winter season. The application of 40 and 80 ppm NAA in guava during the rainy season, acidity content of the fruit was slightly reduced [54]. Pruning treatment in Allahabad Safeda variety of guava causes lower acidity [37]. It has found minimum acidity in both the seasons by the spray of NAA@100 ppm [29]. While, it has been reported that the acidity of fruits was reduced in the rainy and winter seasons with the spray of NAA@100 ppm [42].

e) **Pectin:** It is an important component of guava fruit which is influenced by various treatments of pruning, chemical thinners, plant growth regulators, season of cropping and water stresses. It was reported that the highest percentage of pectin in guava fruits was achieved by the manual removal of flowers [42]. Application of 2, 4-D @ 12 ppm increased the pectin content in fruits of

commercial cultivars [53]. But the application of NAD @ 50 ppm increased the pectin content significantly [42]. Whereas the spray of 4 and 6 percent urea was found to have the highest pectin content when applied twice, in January and July [56].

6. CROP REGULATION FOR ECONOMIC BENEFITS

In India, customers and marketers are always demanding quality guava fruits. The two most popular cultivars of guava, i.e., Allahabad Safeda and Sardar, both are intrinsically poor in quality throughout much of the year [57]. But the winter season crop bears quality fruits that fetch high monetary returns [10]. Hence, crop regulation methodology will facilitate to overcome such issues to an excellent extent by judicious flower thinning during summers. This system can be used to optimize the harvest time, which reduces surplus within the market, to get a higher value of the produce, to avoid spoilage due to excessive production at a particular time, to generate employment throughout the year and balance the trade and to reduce imports. According to research, maximum and statistically higher yield (119.73 q/ha), gross return (Rs. 32925 per hectare) and net return (Rs 230529 per hectare) as well as cost benefit ratio (1:3.33) were obtained under the application of 800 PPM NAA plant growth regulator [58]. Similarly, it was reported that a significantly higher yield (100 kg/tree) was found in Allahabad Safeda with the spray of 10 % urea during the winter season, while Sardar guava recorded the highest yield (103.98 kg/tree) with the spray of 1800 ppm ethephon during the same season which was closely followed by 20 and 15 % urea (100.25 and 96.38 kg/tree, respectively) [10]. It was also found to have the highest benefit: cost ratio (i.e., 7.84:1) by summer deblossoming with spray of NAD@ 60 ppm [59]. Similarly, it was also noticed that the Pant Prabhat cultivar was more profitable with cost: benefit ratio of 1:2.96 by one leaf pair pruning of fruited shoots [60]. This treatment recorded the highest return, which was distributed in rainy as well as in winter season.

7. CONCLUSION

Crop regulation in guava can be adopted successfully by using various cultural and chemical methods. Differential studies by research workers have substantially advocated that the application of various cultural and chemical methods is effective to regulate the flowering of summer season flowers and to produce fruits in winter. The outcome of different studies reported by scientists in guava has revealed that the fruits of winter season were considerably superior in each respect, like attractive size, weight and better internal bio-quality parameters than the fruits of rainy season which helped to fetch the remunerative price of fruits to growers as an well as affordable price to consumers. Depending upon the supply of workforce and chemicals, an appropriate technique suited to edaphic conditions ought to be adopted to get a higher quantitative and qualitative outcome of fruits from guava orchards.

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